Advanced GPS Technology For Automated/Autonomous Shuttle Missions

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I'll be covering .....

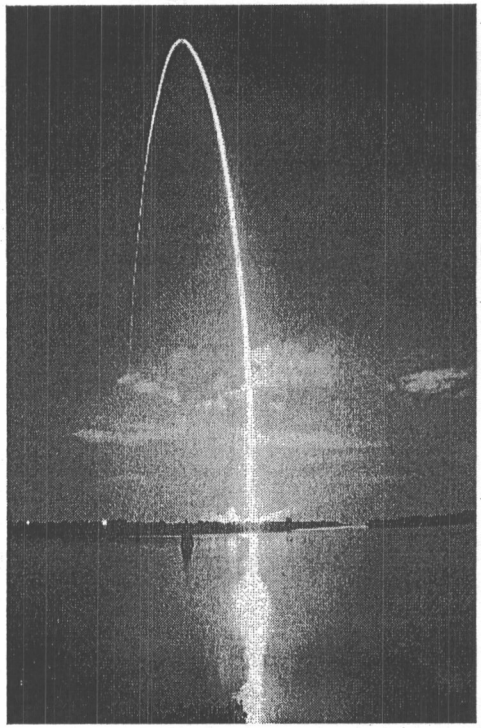
GPS currently on the orbiters.

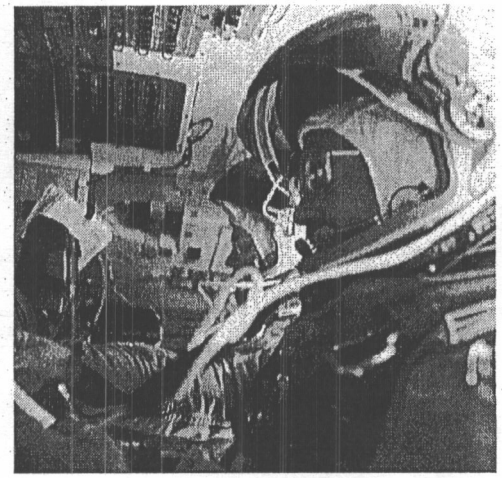
Why we have a 5 channel receiver.

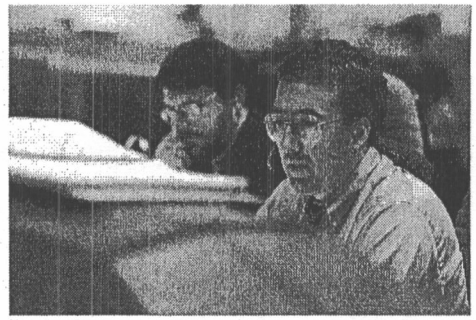
Advantages of a state-of-the-art receiver.

Leveraging lessons learned.

What is happening today with GPS and the Space Shuttle?



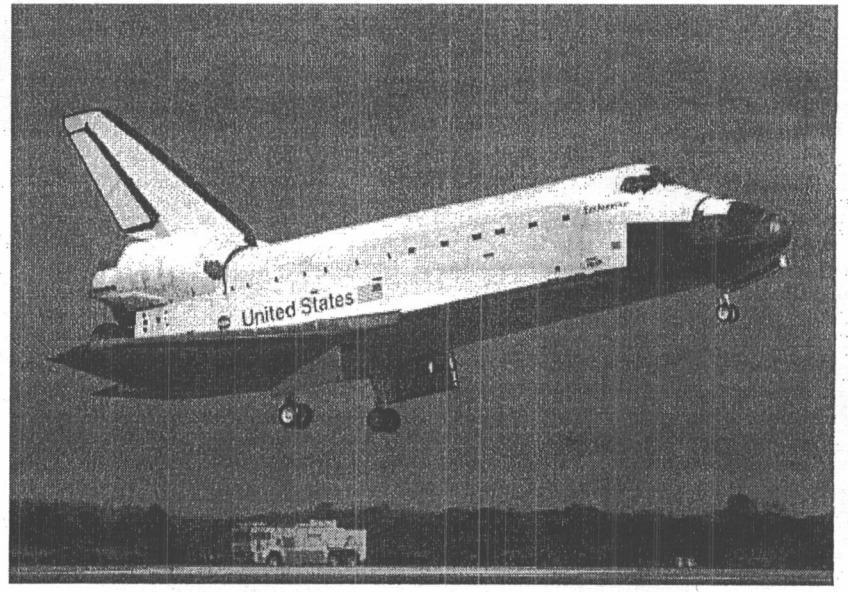




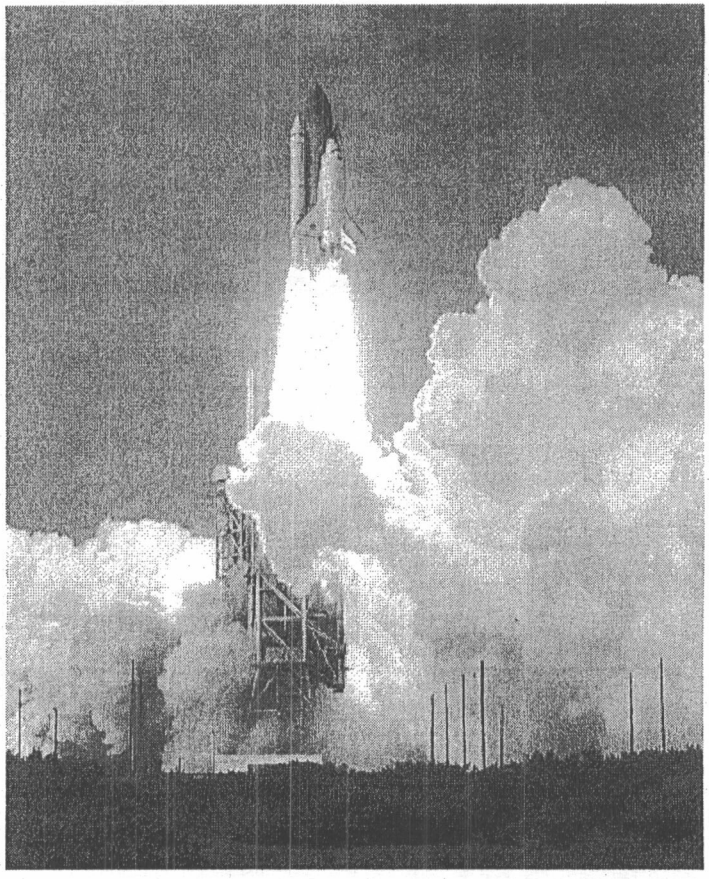
Test flights of a GPS receiver to replace TACAN began in 1996.

Each orbiter has one GPS receiver.

After RTF, ramp-up to single string GPS use will commence.

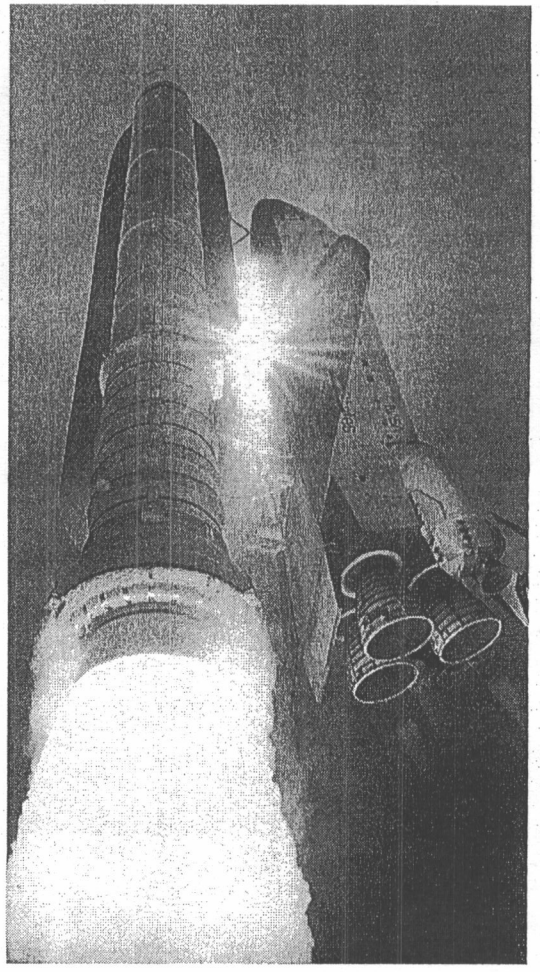


Endeavour undergoing TACAN removal and upgrade to three string GPS.

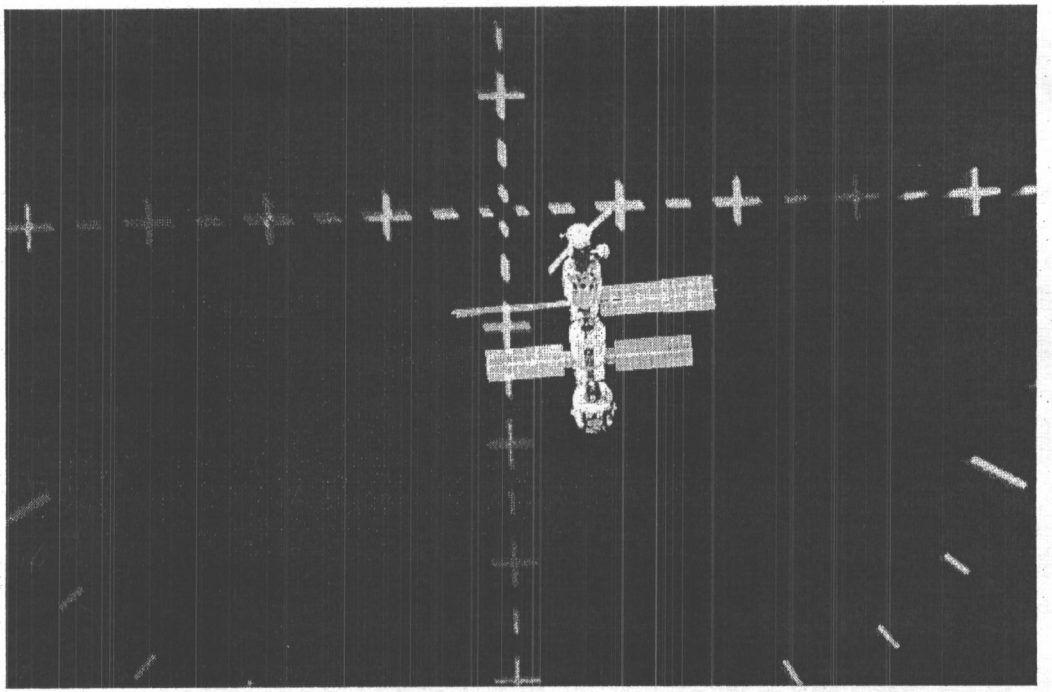


GPS not used for ascent.

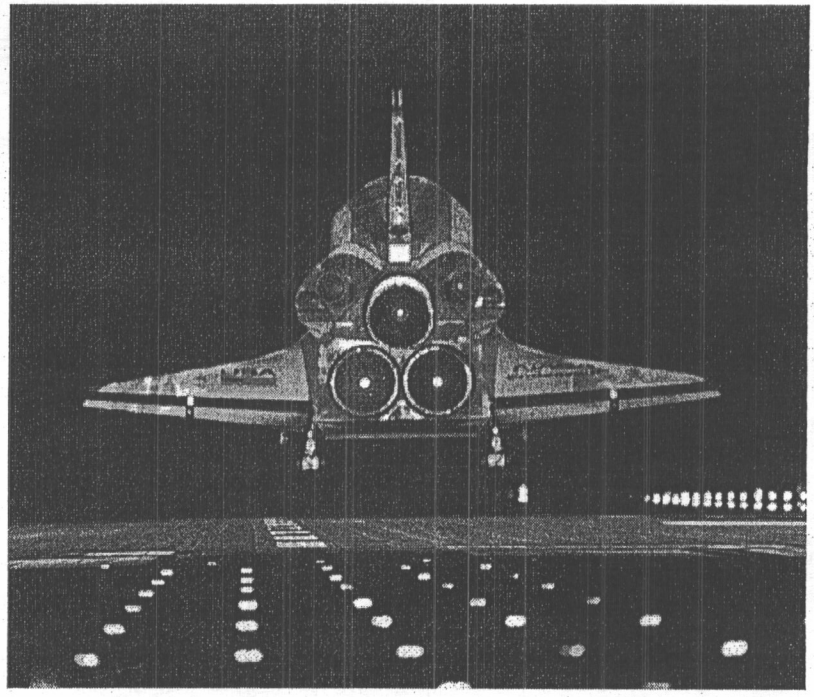
GPS powered on prelaunch to support an emergency landing.



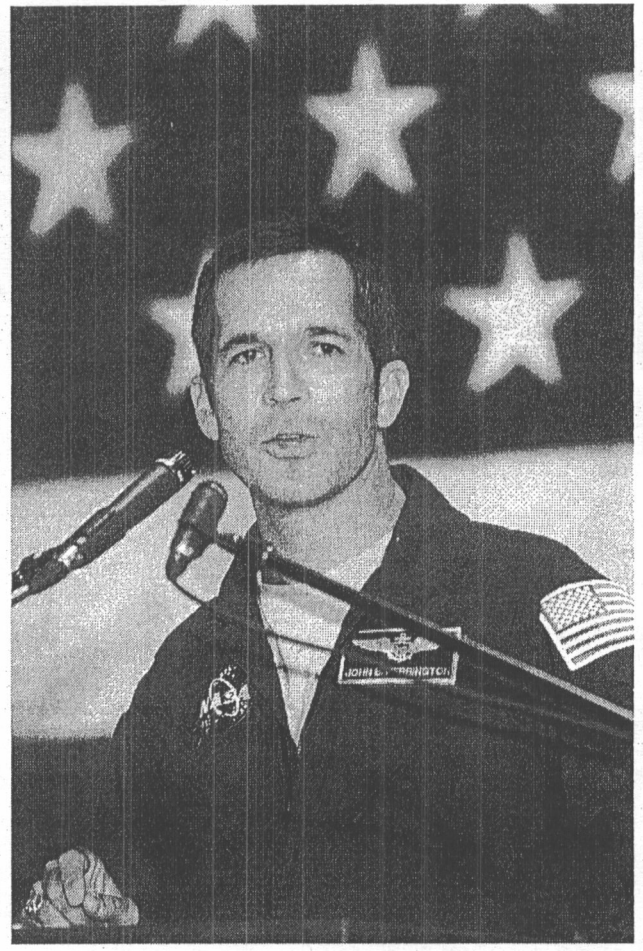
Limited Use Of GPS For Orbital Operations, Not Used for Rendezvous and Docking



GPS will supplement or replace TACAN, but cannot not be used as an MLS replacement.



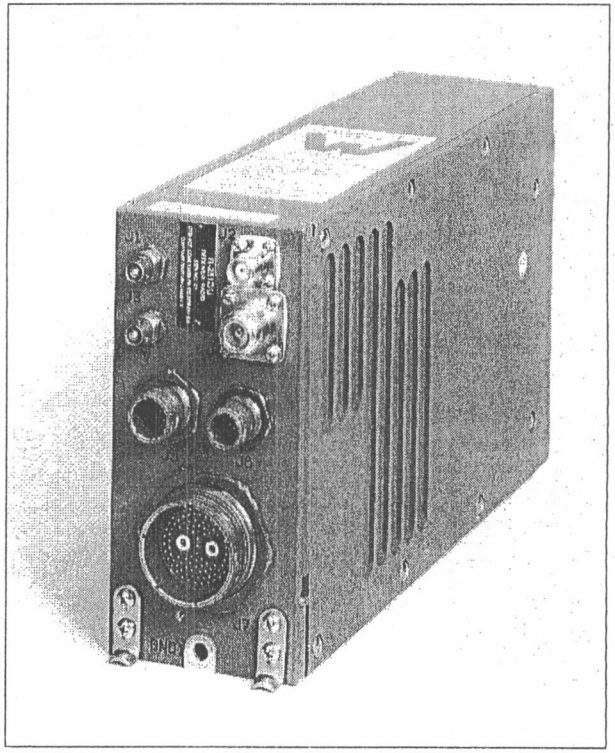
GPS enhances Shuttle navigation and improves safety.



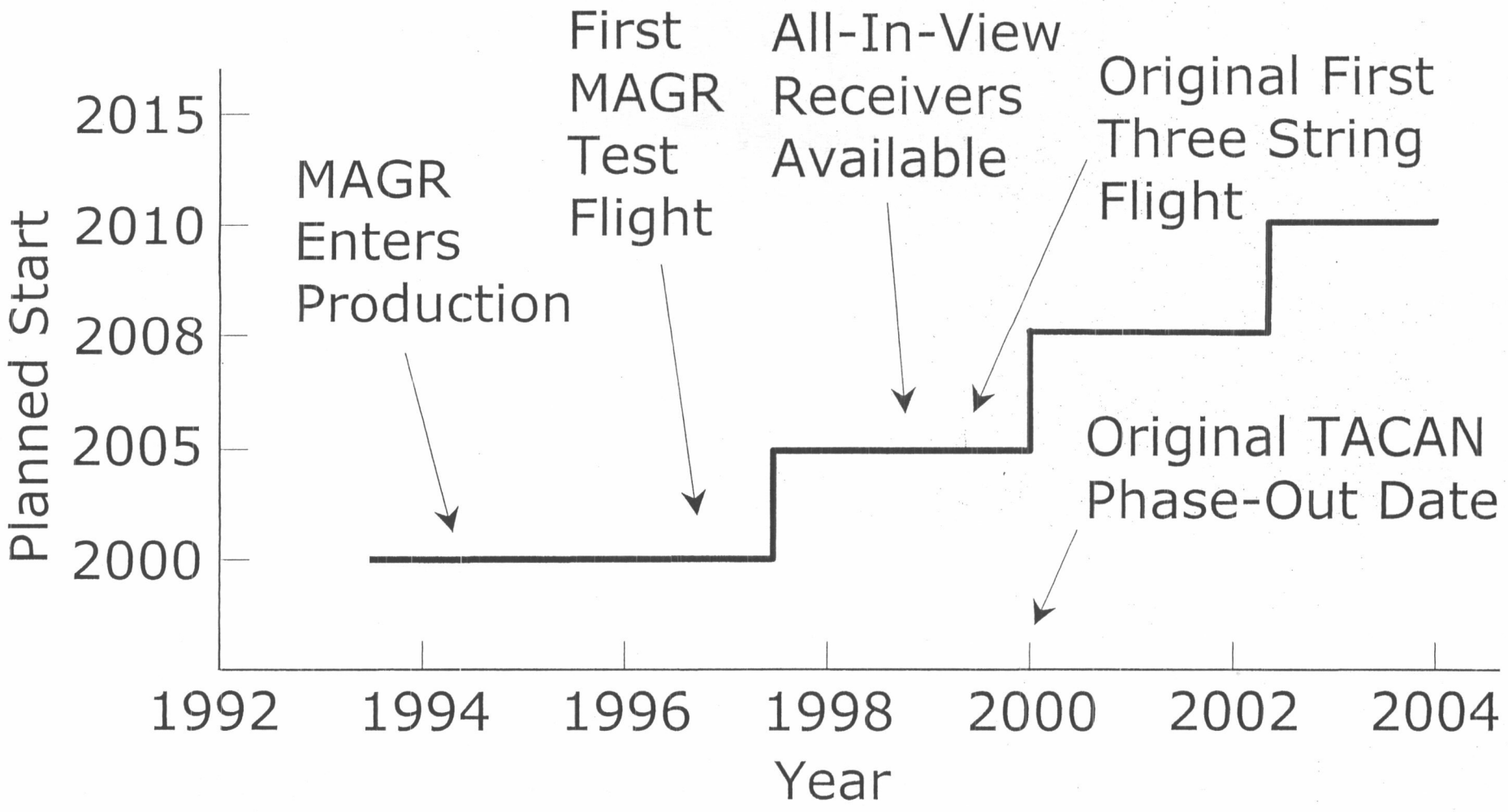
If I can buy an all-in-view receiver for ~$100, why use a 5 channel MAGR receiver?

Aviation receivers much more complex than consumer models.

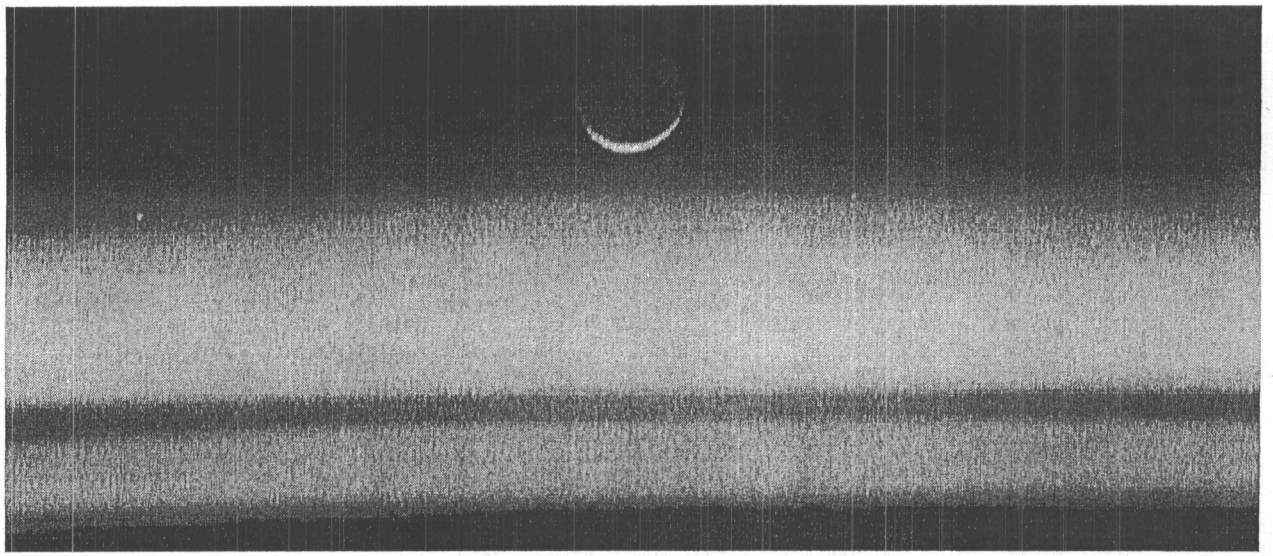
Long lead time required for certification.



5 Channel Receiver Selection Driven by Anticipated TACAN Phase-Out



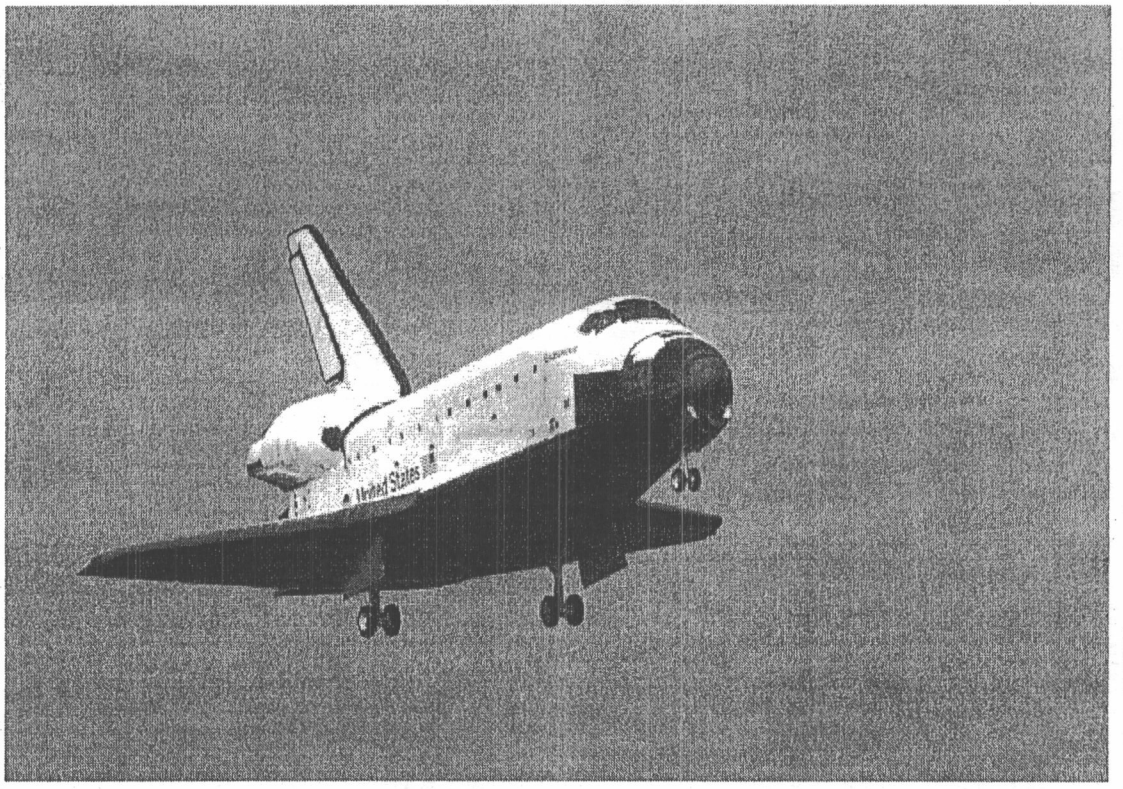
What about the future?



State-of-the-art GPS receivers have capabilities that would be useful in supporting automated/autonomous missions.

Automated landing.

State-of-the-art GPS navigation could provide advantages over legacy MLS.



Joint Precision Approach and Landing System (JPALS).

In development for NAVY, Air Force & Army.

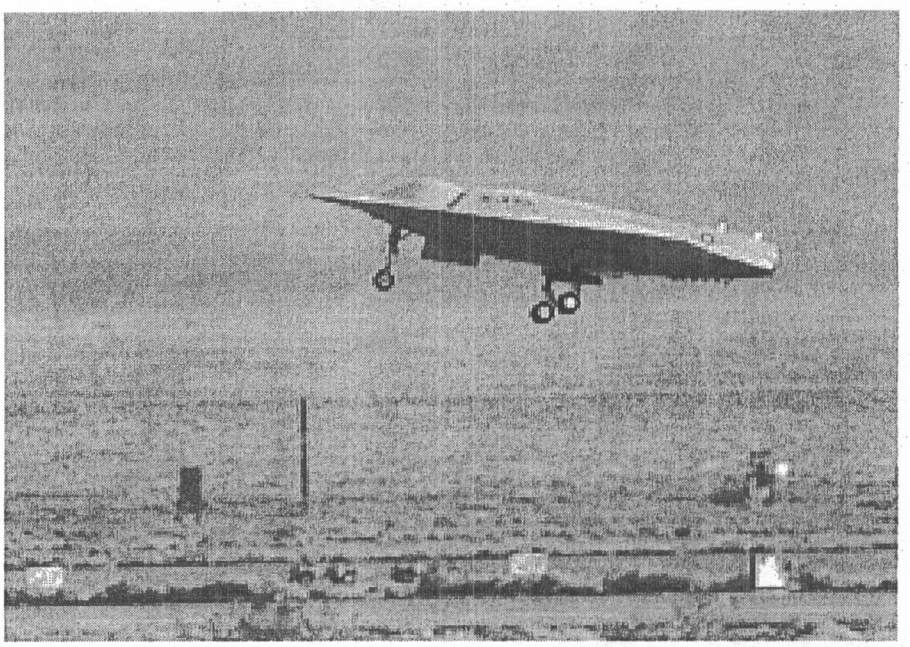
Provides high accuracy, high integrity differential GPS data to support CAT I II & III, all weather landings.

Naval version will support automated carrier landings.

Automated landings using developmental naval JPALS flown with a F/A-18 on USS Roosevelt in April 2001.

JPALS will play an important role in the increasing use of unmanned air vehicles.

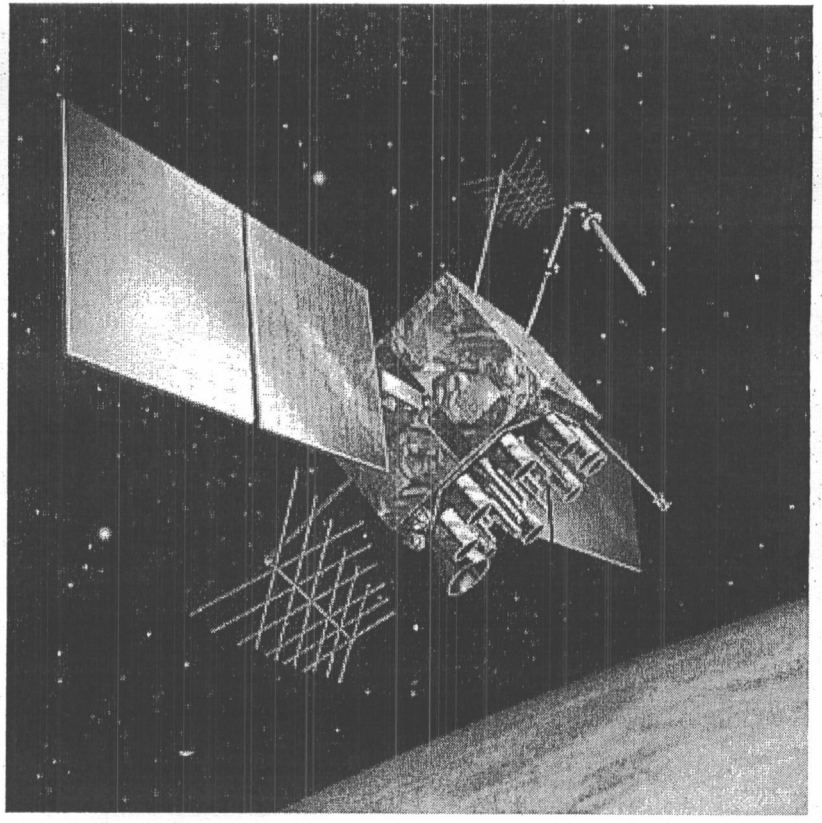
Naval JPALS under evaluation during X-47A test flights.



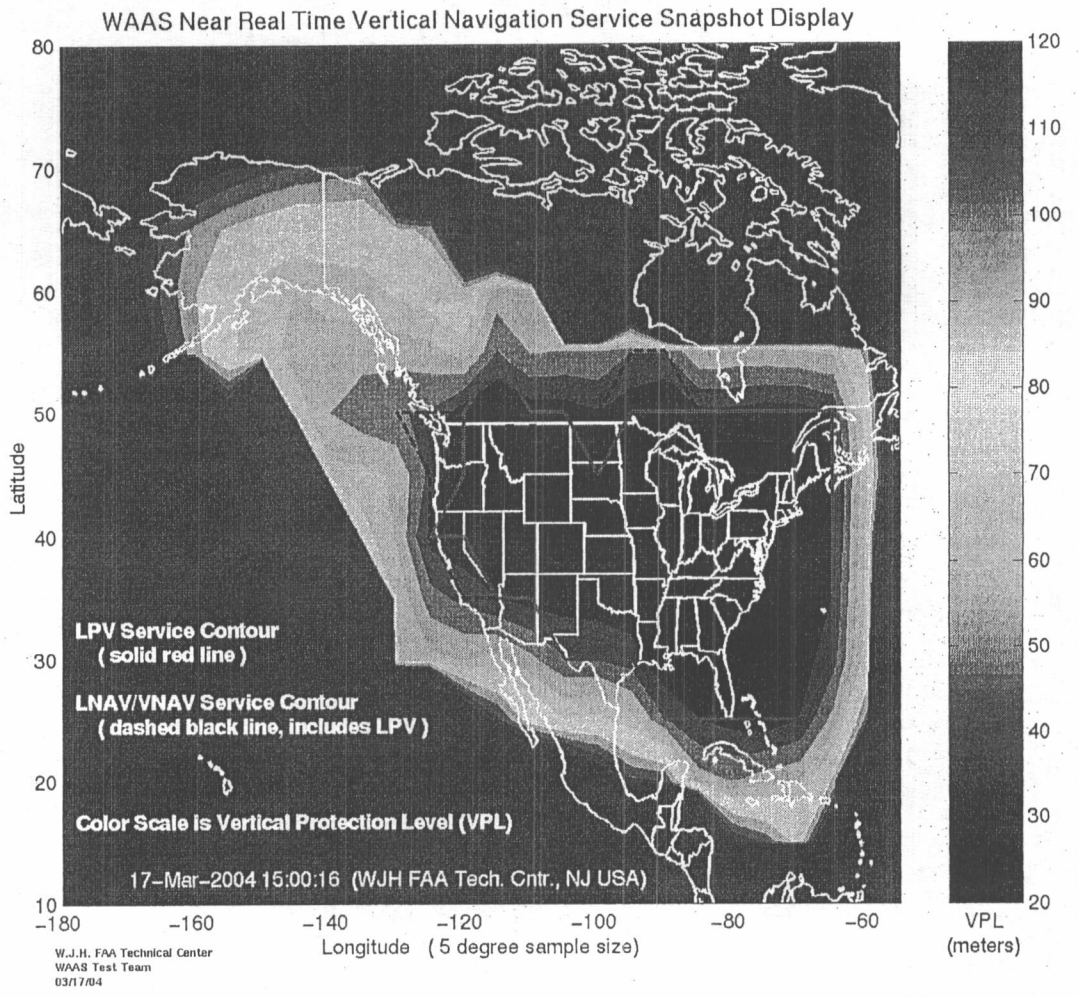
Improved integrity monitoring over current 5 channel receiver.

All-in-view permits on-board Receiver Autonomous Integrity Monitoring (RAIM).

WAAS and JPALS provide satellite integrity information to state-of-the-art receivers.



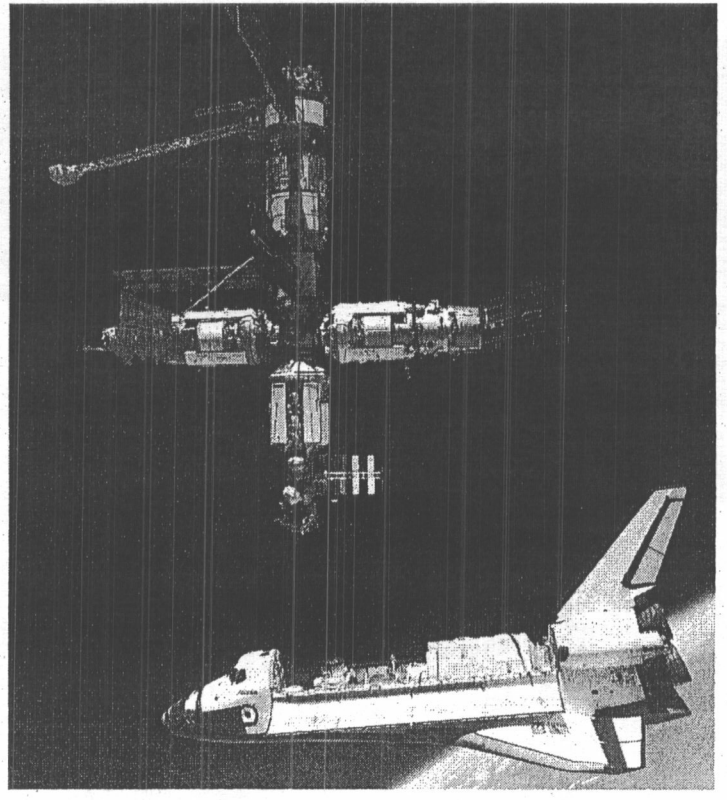
WAAS corrections broadcast to state-of-the-art receivers improves accuracy.



What about using relative GPS for rendezvous?

Would require compatible GPS and comm systems on Shuttle and ISS.

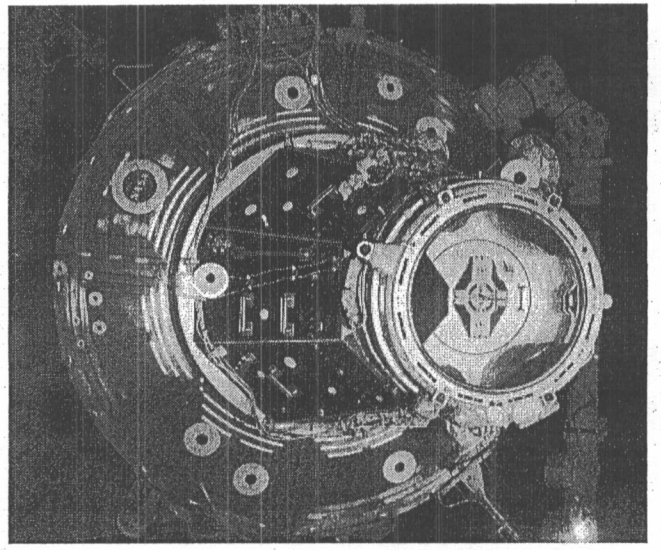
Should be evaluated against other sensors to determine best choice.



What about using relative GPS for docking?

Accuracy requirements, multi-path and satellite obscuration concerns.

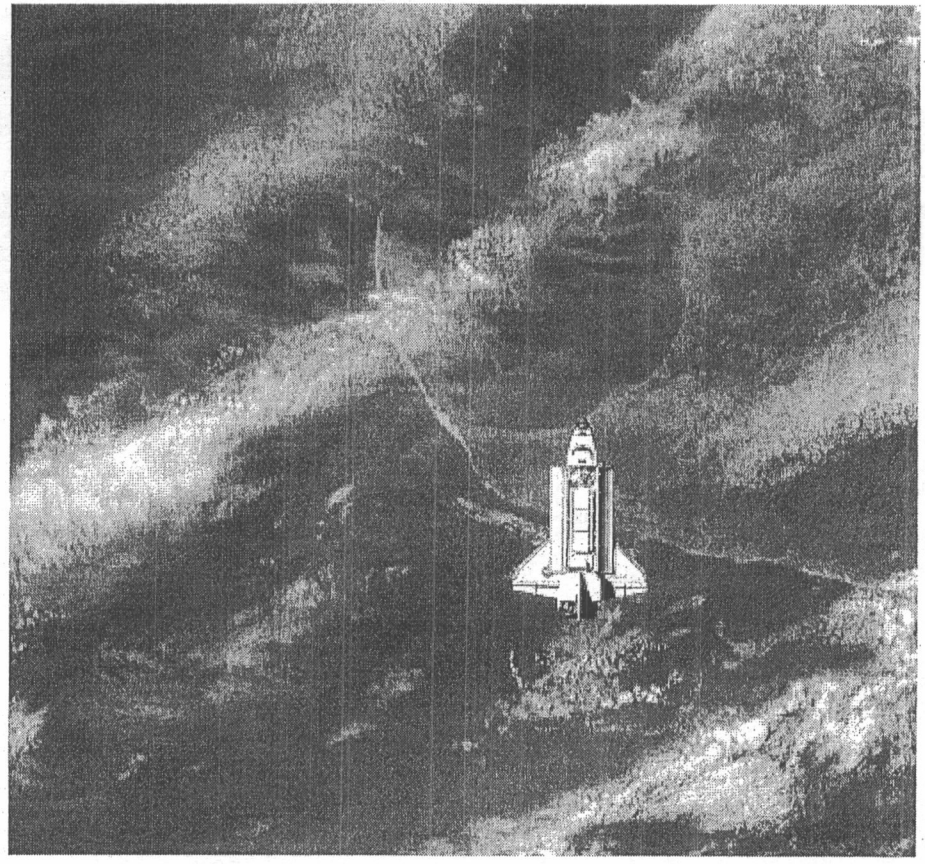
Lasers or other sensors still required for proximity operations and docking.



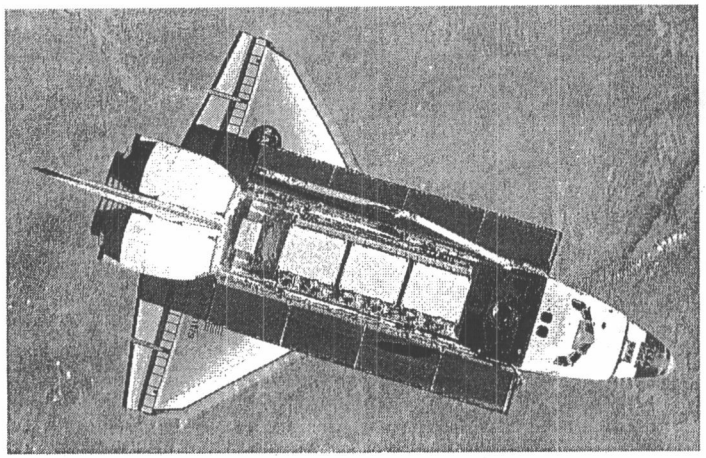
On-board precision orbit determination?

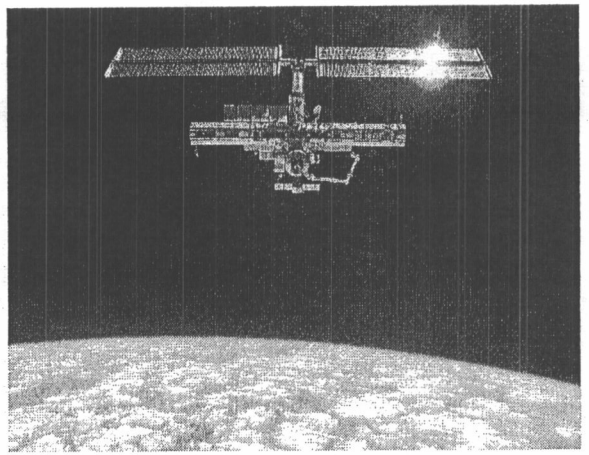
All-in-view tracking could provide some improvement.

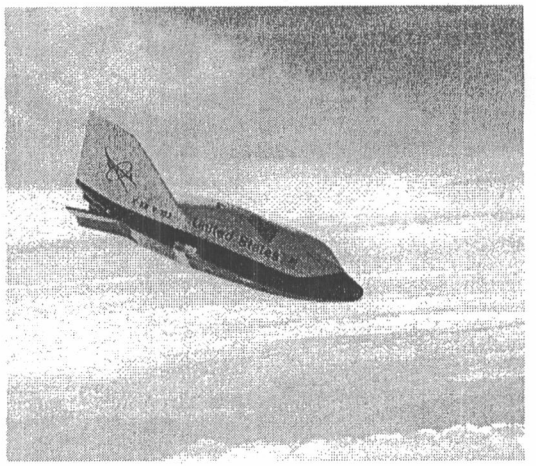
However, high fidelity models, propagators & long term filtering in a computer external to receiver would determine achievable accuracy.



Use Lessons Learned From Past Projects on a Future Shuttle Upgrade





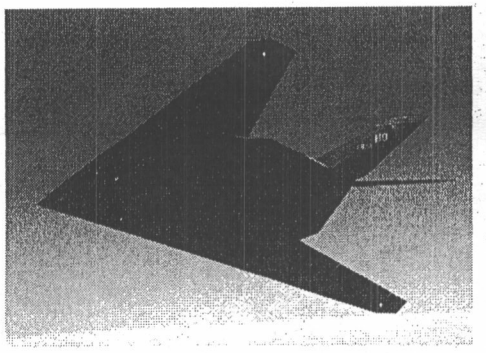


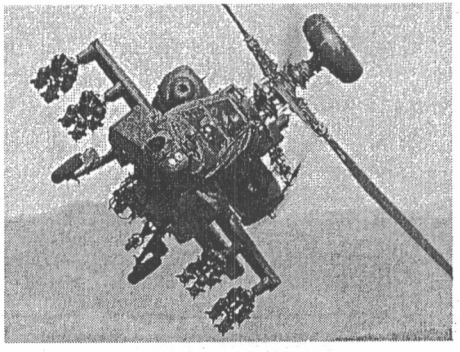
Solution availability was an issue not seen with previous navigation aids.

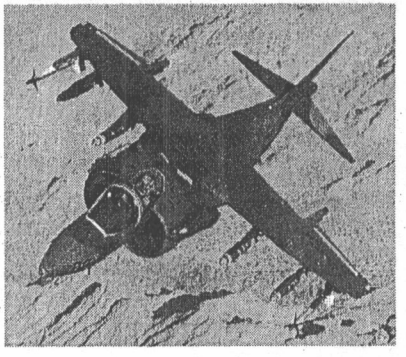
GPS receiver performance is dependent on the radio-frequency environment.

An all-in-view receiver would have a higher level of solution availability than a 5 channel.

"Off-the-shelf" aviation units require extensive testing and modification to support space flight.







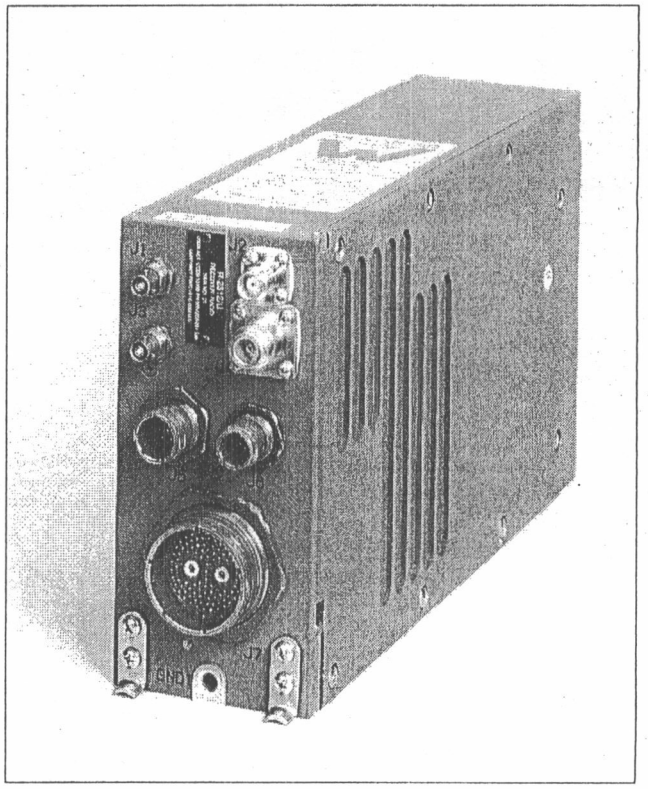
Fly interim software versions.

Receivers test flown on Shuttle:

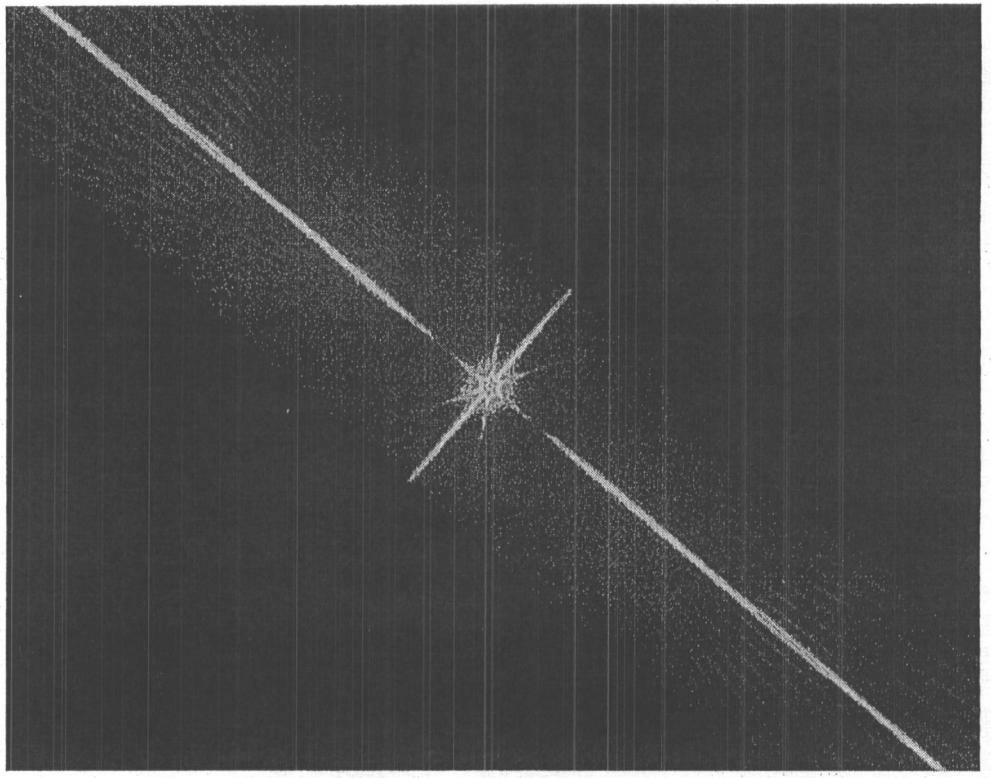
- Shuttle GPS
- ISS GPS
- X-38 GPS

A close relationship with the vendor and good communication among project participants is required for success.

Design insight is critical.



Decreasing size of electronics makes state-of-the-art receivers more vulnerable to radiation concerns.



If future automation or autonomy requirements for the Shuttle emerge, using advanced GPS technology should be studied.

For more information .....

Croft, John, "Pegasus: UCAVs Look Seaward," *Aerospace America*, pages 36-42.Vol. 41, No. 9, September 2003.

Sousa, P., L. Wellons, and G. Colby, "Results of Shipboard Relative GPS (SRGPS) Testing for the Pegasus X-47A Unmanned Combat Air Vehicle (UCAV)," *Proceedings of the Institute of Navigation 59th Annual Meeting*, Albuquerque, NM, June 23-25, 2003.

See the FAA GPS website for information on WAAS and integrity: http://gps.faa.gov/

Goodman, J. L., "Lessons Learned From Flights of "Off the Shelf" Aviation Navigation Units on the Space Shuttle," Lesson #1370 on the NASA Public Lessons Learned System Database website: http://llis.nasa.gov/llis/plls/index.html.